second leads connected thereto, in accordance with a preferred embodiment of the invention;

[0017] FIG. **2**D is an elevation of an HMI including a translatable body, an externally engaged active material spring element and a return spring cooperating to selectively retract and deploy the body, in accordance with a preferred embodiment of the invention;

[0018] FIG. **3** presents perspective views of a reconfigurable HMI being customized by a user, in accordance with a preferred embodiment of the invention;

[0019] FIG. **4**A is a schematic plan of an HMI reconfiguration progression from an initial circular, to an intermediate ellipsoidal, and to a final peanut shape, in accordance with a preferred embodiment of the invention;

[0020] FIG. **4**B is a schematic plan of an HMI reconfiguration progression from an initial circular, to an intermediate circular wave form presenting a plurality of undulations, and to a final circular wave form shape having fewer undulations, in accordance with a preferred embodiment of the invention;

[0021] FIG. **4**C is a schematic plan of an HMI reconfiguration progression from an initial square, to a square having convexly arcuate sides, to a square having concavely arcuate sides, and to a final square having alternating concavely and convexly arcuate sides, in accordance with a preferred embodiment of the invention;

[0022] FIG. **4**D is a plan view of an HMI reconfiguration progression from an initial octagon, to an octagon having concavely arcuate sides, to an octagon having alternating straight and concavely arcuate sides, and to a final octagon having alternating concavely and convexly arcuate sides, in accordance with another preferred embodiment of the invention;

[0023] FIG. **5** is a schematic elevation of an HMI reconfiguration progression from an initial rectangle, to a rectangle having a concavely arcuate top surface, and to a rectangle having a convexly arcuate top surface, in accordance with another preferred embodiment of the invention;

[0024] FIG. **6** is a perspective view of the distal tip of an HMI comprising active material and presenting a raised icon when the material is activated, in accordance with yet another preferred embodiment of the invention;

[0025] FIG. **7**A is an elevational view of the inner-workings of an HMI including a flexible top layer, defining an interior space, and including a shape memory wire functionally disposed therein, in accordance with a preferred embodiment of the invention;

[0026] FIG. **7**B is an elevation view of the HMI shown in FIG. **7**A, wherein the wire actuator has been activated so as to cause a concavely arcuate profile in the layer;

[0027] FIG. **8**A is an elevational view of the inner-workings of an HMI including a flexible top layer, defining an interior space, and including a shape memory wire, pulley and plunger functionally disposed therein, in accordance with a preferred embodiment of the invention;

[0028] FIG. **8**B is an elevation view of the HMI shown in FIG. **8**A, wherein the wire actuator has been activated so as to cause a convexly arcuate profile in the layer; and

[0029] FIG. **8**C is an enlarged view of the HMI shown in FIG. **8**A-B, wherein the wire actuator has been activated and the plunger includes an engaging section operable to form a raised icon or indicia in the layer, in accordance with a preferred embodiment of the invention.

DETAILED DESCRIPTION

[0030] The following description and illustrated embodiments of the invention are merely exemplary in nature and in no way intended to limit the disclosure, its application, or uses. Though described and illustrated with respect to automotive application; it is certainly within the ambit of the invention to use the benefits and features presented herein, in other settings, such as regarding portable, residential, aviation, or commercial building system controls.

[0031] In general, the present invention concerns a reconfigurable tactile human-machine interface ("HMI" or "interface") **10** that utilizes active material actuation to modify its geometric shape, positioning, orientation, and/or otherwise characteristic, such that selection and/or manipulation by a user **12** is facilitated (FIGS. **1**-**6**). As used herein, the term "tactile human-machine interface" encompasses manually manipulated systems controls, and shall include knobs, push-buttons, dials, switches, sliders, balls, and rockers, etc. As is known in the art, manual manipulation of the interface **10** causes input to be received by an associated system (or "machine") **14**. As such, it is appreciated that the interface **10** is communicatively coupled to and operable to modify at least one condition of the system **14**; for example, the interface **10** may be a rotatable knob that presents the volume control of an entertainment system **14**.

[0032] Discussion of Exemplary Active Material Function and Constitution

[0033] As used herein the term "active material" shall be afforded its ordinary meaning as understood by those of ordinary skill in the art, and includes any material or composite that exhibits a reversible change in a fundamental (e.g., chemical or intrinsic physical) property, when exposed to an external signal source. Thus, active materials shall include those compositions that can exhibit a change in stiffness properties, shape and/or dimensions in response to the activation signal, which can take the type for different active materials, of electrical, magnetic, thermal and like fields.

[0034] Suitable active materials for use with the present invention include but are not limited to shape memory materials, such as shape memory alloys, ceramics, and polymers, magnetorheological elastomers, thin strips of piezoceramic bi-morphs, thin films or pockets of MR fluid, and EAP diaphragms/tendons/roll actuators/etc. More preferably, it is appreciated that a dielectric elastomer EAP (i.e., a dielectric elastic film disposed between two electrodes) is especially suited for use in the present invention. Moreover, as used herein the term "active material" shall further include compositions of paraffin wax and other materials that exhibit significant (e.g., at least 8%) volumetric change during thermally induced solid-liquid phase change.

[0035] More particularly, shape memory materials generally refer to materials or compositions that have the ability to remember their original at least one attribute such as shape, which can subsequently be recalled by applying an external stimulus. As such, deformation from the original shape is a temporary condition. In this manner, shape memory materials can change to the trained shape in response to an activation signal. Exemplary shape memory materials include the aforementioned shape memory alloys (SMA) and shape memory polymers (SMP), as well as shape memory ceramics, electroactive polymers (EAP), ferromagnetic SMA's, electrorheo-